Spreadsheet Description Document for Saturation Temperature Calculation

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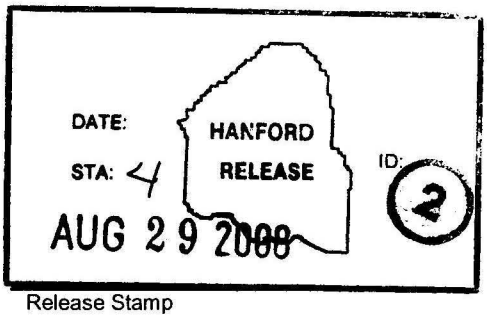
Abstract: This document describes the methodology for determining the saturation temperature in waste tanks. The saturation temperature is used to calculate neutral buoyancy ratio.



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SPREADSHEET DESCRIPTION DOCUMENT FOR SATURATION TEMPERATURE CALCULATION

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LIST OF TERMS

Btu/hr	British thermal units per hour
In	Inch
H_{CL}	Height of Convective Layer (Liquid Height)
ρ_{CL}	Density of Convective Layer (Liquid Density)
H_{NCL}	Height of Non-Convective Layer (Solid Height)
P_{NCL}	Pressure at midpoint of Non-Convective Layer
ρ_{NCL}	Density of Non-Convective Layer (Solids Density)
Pa	Pascal
psia	pound per square inches absolute
WCA	waste compatibility assessment

1.0 INTRODUCTION/OBJECTIVE

Prior to waste transfers into double shell tanks or single shell tanks, the end state of the receiving tank must be evaluated to verify that at least one of the following criteria is met.

a. Total tank heat load is < 58,000 Btu/hr

OR b. Non-convective layer thickness is < 12 in.

OR c. Supernatant depth is < 39 in.

OR d. The non-condensable gas generation rate at saturation temperature in the non-convective layer is sufficiently low, such that the ratio of vertical void fraction profile to the neutral buoyant void fraction (buoyancy ratio) is < 1.0 (*Technical Basis for Tank Bump,* RPP-6213).

If none of the criteria is met, then the waste transfer is prohibited. The first three criteria will be evaluated automatically as part of the waste compatibility assessment (WCA). If the first three criteria are not met, then further evaluation of the buoyancy ratio will be undertaken.

This document describes the methodology for determining the saturation temperature in waste tanks. The saturation temperature is used to calculate neutral buoyancy ratio.

A multiuse spreadsheet, *Sat Temp.xls* (henceforth, the Spreadsheet), incorporates the methodology and will be used to perform the calculation of saturation temperatures.

1.1 Saturation Temperature Spreadsheet

The saturation temperature spreadsheet consists of 4 worksheets as outlined in Table 1-1.

Table 1-1 Spreadsheet Structure

Worksheet Title	Type	Description
Documentation	Information	This sheet contains the spreadsheet title, version, SVF number, owner and location and the purpose of the spreadsheet. It also contains a description of the methodology used and assumptions for using the spreadsheet.
Instructions	Information	Instructions for use of spreadsheet.
ChangeLog	Information	Change log of changes and/or corrections made to spreadsheet, required by errors discovered in the spreadsheet and changes made to criteria.
Sat. Temp	Data Input Calculation	Liquid density, liquid height, solid density, and solid height from WCA are entered. Calculates adjusted pressure. User enters temperatures and pressures from the steam table using adjusted pressure. Saturation temperature is calculated.

2.0 ASSUMPTION

The following assumption is used for the spreadsheet:

- Constant ambient pressure is 1.01E+05 Pa

3.0 METHODOLOGY

This section describes the spreadsheet methodology used to perform saturation temperature calculation for the non-convective layer.

- Enter liquid density, liquid height, solid density, and solid height from waste compatibility assessment.

  Pressure at midpoint of Non-Convective layer is calculated, RPP-6213 (5.1.3):

  $P_{NCL} = P_{ambient} + (\rho_{CL})(g/gc)(H_{CL}) + (\rho_{NCL})(g/gc)(H_{NCL})/2$

P_{NCL}	Pressure at midpoint of Non-Convective Layer
H_{CL}	Height of Convective Layer (Liquid Height)
ρ_{CL}	Density of Convective Layer (Liquid Density)
H_{NCL}	Height of Non-Convective Layer (Solid Height)
ρ_{NCL}	Density of Non-Convective Layer (Solids Density)
g	9.81 m/s^2
gc	1 $(kg.m/s^{2)}/N$

- Use vapor suppression factor of 0.85 (RPP-6213 5.14) to calculate adjusted pressure:

  $P_{adj(Pa)} = P_{NCL}/0.85$

- Converts adjusted pressure from Pascal (Pa) to pound per square inches absolute (psia).

  $P_{adj(psia)} = P_{adj(Pa)}*14.696/101325$

- Using the calculated adjusted pressure, input saturated temperatures (T1, T2) and pressures (P1, P2) from a steam table.

- Saturation temperature for waste compatibility assessment is calculated by interpolation.

$T_{sat} = ((P_{adj(psia)}-P_1)/(P_2-P_1)) * (T_2-T_1) + T_1$

$P_{adj(psia)}$	Adjusted Pressure
P_1	Pressure 1
T_1	Temperature 1
P_2	Pressure 2
T_2	Temperature 2

4.0 COMPUTER SOFTWARE USE AND VERIFICATION

Microsoft Office Excel® was used for the spreadsheet. The spreadsheet was verified in accordance with TFC-ENG-DESIGN-C-32, Revision B-6, *Spreadsheet Development and Verification.*

- Software and version: Microsoft® Office Excel 2003 (11.8105.8107) SP2
- File name: Sat Temp.xls
- File location: \\Hanford\Data\Sitedata\Harmony, in the folder: V:\Compatibility\Stand Alone Evaluations\Flammable Gas Evaluations\Neutral Buoyancy.
- File owner: J. Jo
- Spreadsheet Verification and Release Form number: SVF-1519, R0

Software name and version of any add-in software used: N/A

5.0 RESULTS

The Spreadsheet, Sat Temp.xls has been verified as correctly calculating saturation temperature. The methodology is described in Section 3.0 of this document and is under the assumptions in Section 2.0.

6.0 REFERENCES

RPP-6213, 2006, *Technical Basis for Tank Bump,* Rev. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-ENG-DESIGN-C-32, 2006, *Engineering Manual*, "Spreadsheet Verification," Rev. B-6, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-SD-WM-OCD-015, 2008, *Tank Farm Waste Transfer Compatibility Program*, Rev. 18B, CH2M HILL Hanford Group, Inc., Richland, Washington.

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